COMPUTATIONAL THINKING ACTIVITIES FOR PRE-LITERATE CHILDREN

ABSTRACT

Computational thinking skills are a crucial part of problem solving, scientific inquiry, and coding. Although it is important to expose children to these skills early on, very few activities are designed for a pre-literacy age. This workshop introduces 6 activities that teach a computer science concept through hands-on activities suitable for pre-literate children as well as older children. These activities are intuitive, low-cost, interactive, and readily integrated into the K-6 curriculum. Post-questionnaire results indicate that everyone is more likely to consider coding activities with their children and to recommend a future activity to their friends and family. Our hopes in this workshop is to provide participants with the materials, concepts, and instructions needed to execute these activities in their own classrooms.

Keywords: *Computational thinking, unplugged activities, arts and crafts, encryption, algorithms, coding, animation, photo forensics, human-computer interaction*

Computational Thinking for the Pre-Literacy Age

Recent research has emphasized the need to foster computational thinking skills at a young age. Many approaches make use of software tools (e.g., Scratch) to encourage coding for older children. Recent research and commercial products also promote using hardware tools (e.g., LEGO Mindstorms, Ozobot) to engage children in activities where they can physical manipulate an object. While software programming tools are effective at promoting programming concepts, they require mastery of abstraction skills and are not appropriate for young children at a pre-literate age. On the other hand, commercial toys remain costly to purchase and their design are often limited to solving mazes. There is a need for a larger variety of low-cost activities that allows young children to gain exposure to computational thinking skills. To this end, we have designed six low-cost activities that allow children to learn about computational thinking concepts through the use of arts and crafts materials (although some activities involve the use of a smartphone or a computer). In this workshop, we present these novel activities, their outreach context, and our experience with them.

Outreach Event Context and Activities

As part of a larger university community outreach event, our department organized a "Computer Science Booth" for our visitors in the fall of 2019. Visitors vary in age, background, and interests. Our booth promoted the theme of "Kids Can Code" and was advertised to various local daycares, schools, public bulletin boards, and social media.

We designed six stations for visitors. Each station focused on a unique computer science concept, involved a hands-on kid-friendly activity, and accompanied by more sophisticated worksheets and scientific explanations that are more suitable for an older age group. The concepts and hands-on activity for the stations are: encryption, algorithm, coding, animation, photo forensics, and alternative user interfaces. Each of these activities are described below. Participants in this workshop will learn the concepts involved in each of these stations and be given materials to do the activities involved.

The Encryption Station

Encryption is the process of sending secret messages in a way that only the people involved will understand. That means, if I want to send a secret message to you with others understanding it, you and I have to decide on a way to change how we talk and then only talk in that way. When we change a regular message into a secret message,

that message is “encrypted”. Morse code is an example of how messages can be encrypted. Instead of using regular words and letters, we use short sounds and long sounds for each letter.

- **Task:** Spell your name on paper. Listen to what the name sounds like in Morse code. Pick a key ring and pipe cleaner. Match each letter of the name into the corresponding Morse code. Chain up a round bead for a short sound and a long bead for a long sound. Tie a knot to complete the keychain.
- **Materials Needed:** International Morse code alphabet, pipe cleaners, key rings, round beads, long beads, Morse code app on smart phone
- **Creates:** A beaded keychain
- **Advanced Exercises:** Provide the Ceaser cipher (both original and encoded letters) and ask for encryptions for sample messages such as “SENIORS ROCK MY SOCKS”. Alternatively, ask for a decoding of secret messages such as “WRGDBLVVRFROG”. Additionally, get together with a friend of family member and develop your own method of encryption.

The Algorithm Station

An algorithm is a method of solving a problem. According to the “four colour theorem”, any line picture can be coloured with four colours while ensuring that regions of the same colours do not touch each other. In fact, some pictures only need three or even two colours.

- **Task:** Pick a colouring sheet. Colour white areas using four (or fewer) different colours. Be sure the areas with the same colour do not touch each other.
- **Materials Needed:** A variety of colouring sheets.
- **Advanced Exercise:** Among the various pictures shown, identify the ones that can be coloured with only three (or two) colours while ensuring the regions of the same colours do not touch each other.

The Coding Station

Coding uses a group of instructions to solve a problem. In a maze, the problem is to get from start to finish, and the instructions are the sequence of arrows used to get through the maze. When a problem is too big, we can break it up into smaller problems and solver each subproblem one at a time. When we finish solving all the subproblems, that means we have also solved the big problem.

- **Task:** Solve the maze on the printed worksheet. Next, review the grid maze taped on the floor and sequences of arrows to get through the maze. Note that only one sequence will get to the end of the maze, while others are distractors. Execute the sequences to see which one gets to the end of the maze.
- **Materials Needed:** A printed grid maze, green tape (for the grid), black tape (for the maze wall)
- **Advanced Exercises:** Solve additional grid mazes (printed on paper) by identifying the sequence of arrows needed to get through the maze. Alternatively, use graph paper to create their own mazes to challenge others to see if others can solve their mazes.

The Animation Station

Animation is how we make a sequence of pictures appear as a moving image. Each of these individual pictures in a sequence is called a *frame*. These frames look like a moving animation because our brains process the individual pictures together into a coherent story.

- **Task:** Visitor reviews examples of animation and thinks of something to be animated (e.g., a person flying in the sky). Depending on the age of the visitor, a volunteer may draw a simple animation or help the visitor draw part of the initial frame and then completing the remaining frames of the desired animation. To create an animated GIF, the volunteer uploads the individual frames onto www.ezgif.com, processes them into an animation, and then downloads the animated GIF file for the visitor to keep.
- **Materials Needed** (for flipbook animation): a 3"x3" sticky pad and dark colour pen
- **Materials Needed** (for animated GIF): a digital tablet and pen, drawing software, Internet access
- **Creates:** A flipbook animation or an animated GIF
- **Advanced Concept:** Explanations of programming computer animation using an apple catcher game. Concepts include the geometry of moving images (e.g., falling apple) and collisions (e.g., eating apples).

The Photo Forensics Station

Did you know that some pictures that look real are fake, and some pictures that look fake are real? Why do you think people make fake pictures? Sometimes we can guess whether a picture is real or not. When you're not sure, you can use tools to help you figure out if a picture has been modified. Do you want to take a picture that shows you riding an elephant, dancing in a bubble, or walking on water? We can use that picture and show you how it has been modified.

- **Task:** Choose a photo background. Pose in front of the green screen and take a picture. See yourself in the chosen background. Analyze the image to see how it would compare to a real photo.
- **Materials Needed:** Green screen cloth, camera, green screen app, green screen backgrounds, online access to fotoforensics.com .
- **Advanced Exercises:** Determine whether additional pictures are real or fake. Discuss the concept of "error level analysis" that shows areas of a picture with different levels of compression, indicating areas that have been modified. Discuss the concept of "rainbowing" so that images show areas of red and blue due to resaving of a file.

The Alternative User Interfaces Station

Many devices have computers in them, such as phones, calculators, iPads, and even cars. The design of these devices and whether we operate them by touching, typing, or talking to them are all methods that come from a research area called "human computer interaction" (HCI). Most computer interaction involves a mouse and keyboard. New techniques involve speech and gestures. A fun part of HCI explores the use of common household objects for interaction. Makey makey is a small device that lets you use household objects as buttons for the computer. It uses an electric circuit and wires to tell the computer which object is connected to which button. So if you connect a banana to the space bar, then pressing on the banana will be interpreted as pressing the space bar.

- **Task:** Select the household objects you want to use and assemble a custom piano. Learn to play a song by following the music sheet and using the custom piano.
- **Materials Needed:** Makey makey kit, software set to a piano, household objects such as food with conductive textures (e.g., fruits and timbits), sample music sheets.
- **Creates:** A digital song made from the fruits piano
- **Alternative Exercise:** Did you know that virtual reality is also part of HCI? It is an environment that lets us experience a simulated world that is not physically present. Try on a Google cardboard to experience riding a roller coaster or petting a lion.

Post-Event Feedback and Discussion

All of our stations were full for the three hours of the event. Our survey results indicate that the activities were well-received and more similar activities in the future can benefit young children. In particular, we asked visitors (or their parents) to complete a feedback survey when they leave our booth. Overall, we had 24 completed surveys and a response rate of 75%. To summarize, we created the word cloud below showing a single word or a short phrase that respondents felt most represented their experience.

Lastly, one of the parents later contacted me on Facebook to share a unique story:

> When we left the [events] on Saturday, on the drive home [A] asked: “Dada, when we get home, can we build something with Scratch on your computer?” She hasn’t been interested at all in that before, we’ve taken a bunch of books out from the library over the last two years, each time she says she’s interested while we’re there, and then get zero interest when we get home. But when we got home from the events Saturday, she was super-excited to go to the laptop together, and we spent 45 minutes building some new Scratch games together, and she was interested and excited the whole time and directed the entire process.

We believe the success of these stations are founded on the connection between familiar activities, such as arts and crafts, to coding concepts. Our next step will be focused on developing more related activities and creating toolkits for teachers to use in their classrooms.